Alyeska Reports

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HARALD SUND

Collector system lines await oil at Prudhoe Bay

Tapping

Photographs by Harald Sund

Harald Sund is a free-lance photographer whose work has appeared widely in magazines and books.

Prudhoe Bay's 9.6 Billion Barrels

Fingers of gas safety flare pipe extend over pond

They're developing something like 9.6 billion barrels of oil in Alaska's Prudhoe Bay field along the edge of the Arctic Ocean. That's more proved reserves — in just one field — than currently exist in Oklahoma, Louisiana, Kansas and half of Texas *combined*.

The oil there was discovered eight years ago and, so far, has not returned a single penny for the billions of dollars being invested in the field — not to mention the additional billions expended on the Alyeska pipeline system that will carry the crude to market.

Obviously, the Prudhoe Bay producers are making certain the oil will be ready for delivery just as soon as the Alyeska system is ready to receive it. They've been forced to wait for the pipeline and they vow the pipeline will not have to wait on them.

Titan tasks already have been accomplished in preparation for production. Much remains to be done before scheduled output can be achieved, but the producers say they will be waiting with plenty of wells and plenty of capacity ahead of the pipeline's scheduled mid-1977 initial-stage completion as well as all subsequent expansions.

Taking full advantage of the nightless Arctic summer, Prudhoe Bay's two operating companies are primed for the final push to bring the field's production level to 1.2 million barrels daily in 1977. Subsequent efforts will be devoted to boosting the flow to about 1.5 million barrels daily and maintaining productive capacity.

The two operators — BP Alaska and Atlantic Richfield Co. (Arco) — acting on behalf of the field's 11 interest-owners, are meeting State of Alaska requirements to develop the field as a single unit to ensure maximum efficient production and environmental protection while avoiding unnecessary duplication of common facilities.

For a normal field in the United States, a single company would act as operator. But the size of the Prudhoe Bay field — it underlies 250 square miles of the Arctic tundra and permafrost — and the extremely hostile environment dictated a minimum of two operators. No single company could spare the management, money and manpower necessary to handle development alone.

By Riley Wilson

Riley Wilson is oil editor of the Tulsa Daily World and has written extensively about Alaska oil developments.

BP Alaska and Arco were chosen by the 11 lease holders to handle operating tasks. Standard Oil of Ohio is another major lease holder. British Petroleum holds a 25 per cent stock interest in Sohio, which will increase to 54 per cent shortly after the field goes into production. Exxon Co. USA is a partner with Arco, contributing to the initial capital investment and assisting in other ways.

However, BP Alaska and Arco management are basically responsible for the field which, for operating purposes, was arbitrarily divided in half — BP Alaska taking the western side and Arco the eastern.

Different techniques are being used by the two operators for some installations and well development, but the two firms are not deviating basically from the approved development plan. This formula includes carefully selected well locations and other facilities to assure fullest and most efficient recovery of Prudhoe Bay's oil as well as its 26 trillion cubic feet of natural gas.

All of the interest-owners eventually will share in the expenses and the production according to ratios currently being developed. The unitization agreement when approved by the State of Alaska, will assign the specific shares based on scientific evaluation of the individual leases covering the productive portion of the field.

Mobil Oil Corp., Phillips Petroleum Co. and Standard Oil Co. (Ind.), as partners in a three-company group, will be assigned shares jointly for subsequent division among themselves. Similarly, a six-company group will receive a single allocation for individual breakdown. The six include Amerada Hess Corp., Getty Oil Co., Louisiana Land & Exploration Co., Marathon Oil Co., Placid Oil Co., and Hunt Oil Co.

Sohio/BP, Arco and Exxon, however, will account for the lion's share of the ownership, although the field is so huge that even a one per cent share is worth about 100 million barrels of oil — a "major" field in the Lower 48 states.

Prudhoe Bay's wells are being drilled directionally from gravel pads — six or eight wells per pad — to bottom-hole locations that will effectively drain the reservoir over the years.

Vertical depth of the oil zone is about 9,000 feet. Because of the angle, linear depth of the wells often approaches 13,000 feet.

Initially, each well will drain an average of about 640 acres, but greater well density will be required in some areas where the oil column is thicker.

Drilling of the wells can continue winter and summer from the pads, which are made of gravel. Some are up to 566 yards long and 78 yards wide, allowing the rigs to be moved from one hole to the next with ease.

Each well takes about 30 days to drill. BP and Arco are using different techniques in their wells, just as they have different programs for handling the oil after it leaves the wellheads. But the effects are the same.

Once through the permafrost, the drillers carry the holes into the oil-bearing formation, install pipe and the wellhead equipment, called Christmas trees. These shut in the well until production is needed. At that time, rigs will be returned to "perforate" the pipe in the wells to allow the oil to flow from the formation rocks into the production facilities. Because the wells on the slope flow naturally due to gas pressure, no pumping units will dot the landscape and only a few rigs doing maintenance or additional development drilling will be found throughout the 250 square miles.

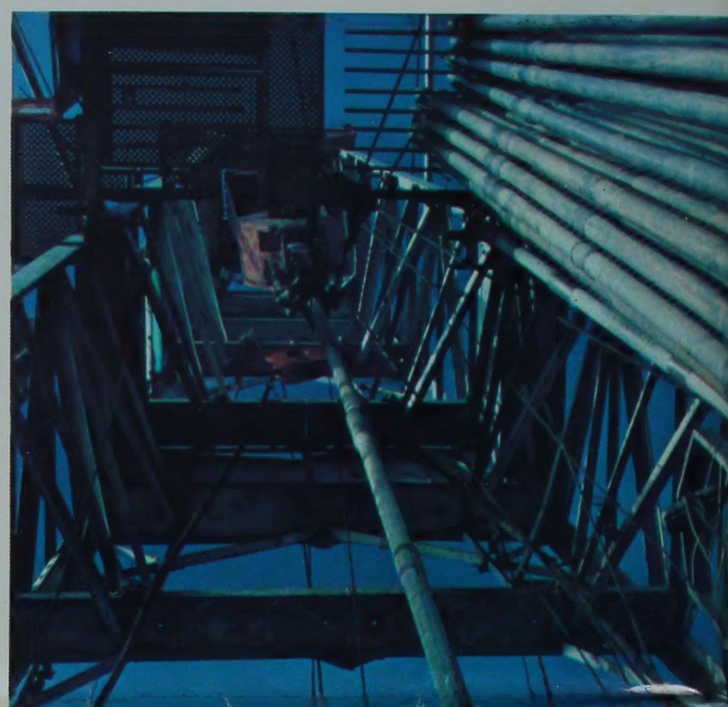
BP is using seven inch pipe to carry the oil out of the ground and Arco is using five inch, but average flow will be about the same. Currently, BP is using two drilling rigs — including a mammoth unit especially designed for mobility in the Arctic environment. Arco is using five rigs.

When on stream, wells will be tied into production facilities strategically located throughout the field. These facilities — called "gathering centers" by BP and "flow stations" by Arco — will handle about 300,000 barrels daily of crude each from 24 to 26 wells.

In 1977 there will be two centers in operation on each side of the field with a capacity of 1.2 million barrels daily. A third center on each side is under construction, giving a maximum production capability of 1.8 million barrels daily. However, when these are in operation, production probably will not exceed 1.5 million barrels daily, carefully allotted among all wells. This will provide flexibility necessary to maintain total production while some wells are shut in for routine maintenance.

BP is laying flow lines from each individual well directly into its "gathering centers" while Arco is combining oil from individual wells at the drilling pads, then moving the crude to its "flow

1) Standing pipe awai use in drill rig, 2) Drill r crew positions pip 3) "Christmas tree" ca drilled well, 4) Drill rig Prudhoe Bay, 5) Worke link pipe at ga compressor plan 6) Control room at centr gas compressor plan 7) Control panel at B power plan



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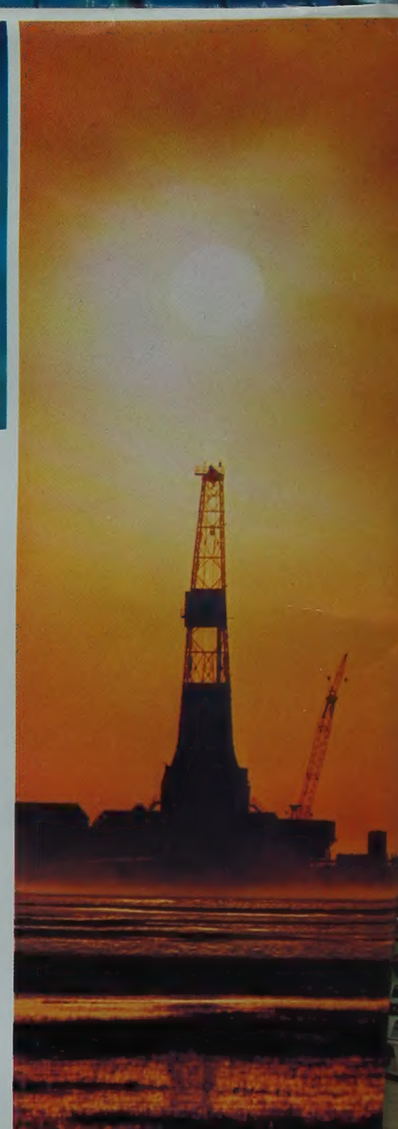

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stations" by a common line. At the center/stations of the two firms, however, virtually the same thing happens. The crude oil will pass through equipment which separates it from the natural gas and small volumes of water that are mixed with oil. The crude also will be cooled to about 140 degrees Fahrenheit and then delivered, through further pipelines, to the Alyeska Pump Station No. 1.

Water recovered from the crude will be treated and reinjected into disposal wells at the station site.

Natural gas taken from the oil will go through huge lines to a single, giant compressor plant on the Arco side of the field which includes the "gas cap" that overlies the oil formation.

Here, the natural gas will be compressed and, mostly, reinjected into the gas cap to await the eventual completion of a system pipeline to carry the natural gas to market. When this occurs, the compressor plant — thanks to its design — can be utilized to pump gas down the gas pipeline.

A lot of the gas, however, will be utilized at the compressor plant and at the mammoth central power station, which will provide electricity to all facilities at Prudhoe after completion of subsequent stages of construction. With the equipment now in place, it already is contributing greatly to electrical power needs. Also, some gas will power Alyeska's pump stations on the North Slope.

At all gathering center flow stations, and at the compressor plant, elaborate safety precautions have been taken for handling the gas. Included are flare systems through which the gas can be funneled for emergency burning in case of malfunctions.

Again, BP and Arco have taken different approaches to achieve the same results. BP will utilize a few big vertical flares designed to channel radiated heat away from the tundra while effecting such complete combustion that the flames will be almost invisible. Arco prefers a horizontal system with thousands of little flares — like candles on a cake.

As with the Alyeska Pipeline itself, the Prudhoe Bay field's operators are incorporating designs to accommodate Arctic wildlife including the caribou. The ribbons of pipelines through the field are buried in places to provide caribou crossings.

For year-long access to all sectors of the field, a 30-mile

"spine-road" was constructed with other roads shooting off as necessary. Built of gravel five-feet thick to protect the tundra and permafrost, roads in the field now total about 130 miles.

In addition to the commercial airstrip at Deadhorse, on the edge of the field, a Prudhoe Bay strip also lies in the active area. Next to this strip, Arco built its operations center, completing the first section in the summer of 1970.

A spacious two-story complex, it consists of a central building with living quarters, water supply system, power generation system, vehicle storage, maintenance shop and warehouses. Initially designed to house 210 workers, the center will be expanded after the 1976 sealift to accommodate 440 personnel.

Eight miles to the northwest is BP Alaska's three-story operations center, a three-year-old self-contained complex that accommodates 140 people with built-in expansion capabilities for 124 more as a result of the 1976 sealift.

Both the BP and the Arco centers are designed to withstand the rigors of the Arctic while helping workers avoid claustrophobia in the dark, sub-zero winters.

BP's multi-million dollar structure includes a glass-enclosed arboretum landscaped with trees and tundra flowers plus recreational facilities that include a 40-foot swimming pool which doubles as a reservoir for fire-fighting purposes.

In addition to the operations centers, BP has built two 500-man construction camps and Arco has built one camp capable of handling 1,750 workers engaged in the installation of facilities. These work camps are used by employees of contractors and subcontractors, mainly.

Among the other early installations at Prudhoe Bay were a small crude oil processing plant opened in 1969, and an electric generation facility.

The "topping plant" uses about 13,000 barrels of crude oil daily from nearby wells. However, the output of useable products — diesel fuel and a naphtha-type gasoline — amounts to a maximum of 3,500 barrels daily. The residue is reinjected into the oil reservoir below ground.

Also installed at Prudhoe Bay in 1969 was a dock and staging area on the southeast shore to handle sea shipments. Subsequently a new dock was built about 10 miles to the northwest and a 5,000-foot extension was added last winter to reach the deep-draft barges which were caught in the ice before being able to unload their cargoes.

The docks have allowed BP and Arco — as well as Alyeska — to utilize barge operations from the lower 48 states. Because barge transportation was available, buildings for the operations centers and many other installations were prefabricated as modular units in the lower 48 and shipped to

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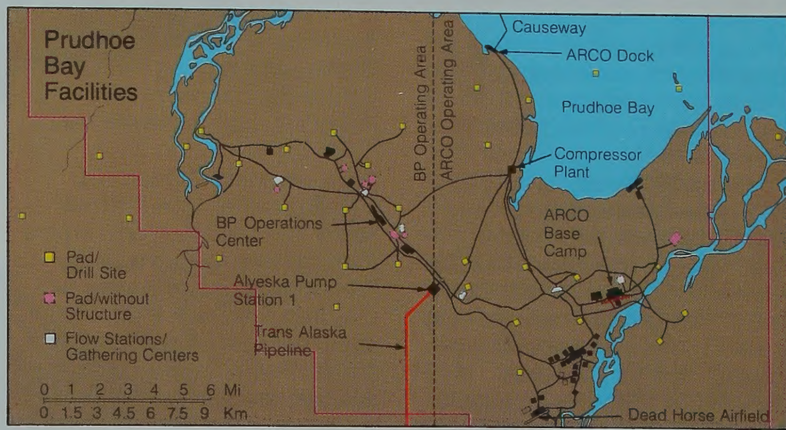
Prudhoe Bay by sea. At the docks, crawler units — like those used to move space rockets onto their pads — carried the modules off the barges to their positions ashore.

Sometimes the barge convoys have been massive. In 1970, 70 barges carried 187,000 tons of cargo. And sometimes the barges haven't made it because of the contrary Arctic ice pack. In 1975, some tugs and barges turned back and others were stopped short of the docks.

This year's sealift, of about 60 modules and skid-mounted units provided more facilities necessary for the initial 1.2 million barrels of production daily.

Prudhoe still, however, relies heavily on aircraft, particularly for personnel, mail, rush-cargo and perishable items. Aircraft haul about 1.2 million pounds a month. Trucks move additional supplies over the Yukon-Prudhoe haul road which links to the State highway system.



At this time, the Prudhoe Bay field resembles for all the world a military operation with thousands of workers, hundreds of vehicles of all types and scores of structures in various states of readiness.

Once production is established, however, all of that will change drastically. The two operations centers will house most of the permanent personnel and the control facilities. Construction workers will return to wherever they came from, and Prudhoe will start becoming a mature field with a minimum of activity.

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1) Generation plant provides electric power for field activities, 2) Feeder lines installed, 3) Causeway extends out to sea, 4) Tugs and barges reach Prudhoe Bay, 5) Collector pipes at Flow Station One.

SHOOTOUT IN KEYSTONE CANYON

BY JIM FABER

From its capital city of Juneau to the beaches of Nome, Alaska's history is colored gold. But etched in copper is one of its gaudiest chapters — The Shootout at Keystone Canyon.

By 1906, Keystone Canyon was being hailed as the portal to Alaska's interior. Through it, surveyors had staked out a right-of-way for a railroad that would link Valdez, just 14 miles away, with Fairbanks. Other rails would carry freight as far as Circle on the Yukon River and haul copper ore to tidewater from the new fields in the Copper River region.

During the next three decades, four copper mines would extract more than $200 million in ores from those fields lying in the shadows of the Wrangell Mountains fewer than 150 miles from the sea. Owners of the field included the Guggenheim brothers, J.P. Morgan and other New York financiers organized as the Alaska Syndicate. In Valdez in 1906, they were being hailed as the men who were building the Copper River & Northwestern Railway through Keystone Canyon.

To those in Valdez that summer, the recurrent dynamite explosions at the Canyon, long a favorite spot for picnics and outings, were considered pleasant overtures to the train whistles just around the bend. The townsfolk were ill-prepared for the jarring note that was to set the stage for violence.

Acting on recommendations of railroad-building engineer, Thomas Heney, the Alaska Syndicate announced it was withdrawing from Keystone Canyon. The railroad to the Interior would be built not from Valdez, but from Katalla, about a hundred miles to the southeast on the Gulf of Alaska.

Heney once said, "give me enough snoose and dynamite and I'll build you a railroad to hell." Now he had convinced the Alaska Syndicate he could build one to their copper holdings over a route more profitable, but, on appearance, just about as damned. In 1898, Heney had built the railroad that clawed its way over the White Pass from Skagway to the Klondike gateway community of Whitehorse. That cachet, coupled with the fact that the Katalla route would tap some potentially rich coal deposits, doomed Valdez.

Heney would need more than snoose and dynamite to win his Katalla gamble. His biggest challenge was to be the Copper River, which would have to be bridged virtually mid-point between two vast glaciers, the Miles and the Childs. Bridge builders would face 40 below temperatures and winds up to 90 miles an hour. Cassions would be threatened by huge icebergs dropped by Miles Glacier, only a half-mile upstream. (Later, these challenges paled when it was determined that falsework for the final 400-foot steel span would have to be built on the ice — and completed before the spring breakup!)

In Valdez, feelings against the Alaska Syndicate ran hot and deep over the Katalla project. The change in plans created an ideal climate for the cultivation of the indignant and the gullible. Within a few days, a flamboyant Valdez copper developer, H.D. Reynolds, began the harvest.

Reynolds chartered a steamer, took the town's businessmen on a cruise, then called a mass meeting. When it was over, the town had pledged Reynolds $100,000 as seed money for a start on the Alaska Home Railway, to be built and operated by the people of Valdez, with Reynolds in the cab, of course.

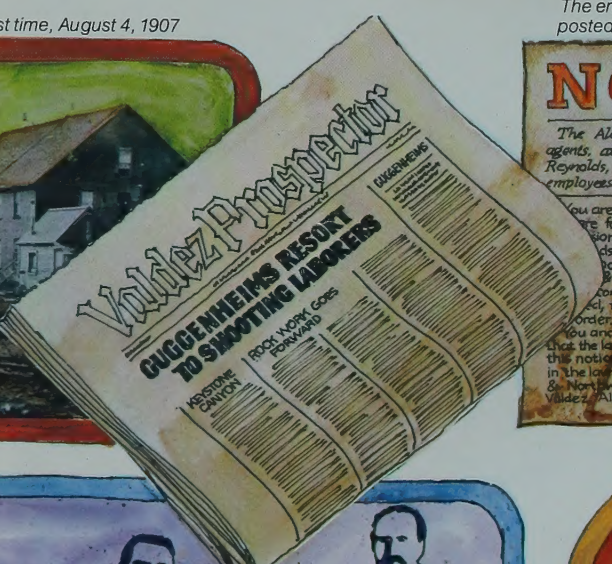
Valdez further responded by giving Reynolds a franchise that gave him control of most of the town (which the promoter had promised to rebuild into a sort of sub-Arctic Athens) and turned over to him a church. Reynolds, who knew a bit about God and mammon, promptly converted it into a bank, causing the few cynics remaining to dub his operation, "Jesus & Co."

By the summer of 1907, the Alaska Home roadbed was inching toward the only barrier lying between Valdez and the riches of the Interior — Keystone Canyon, held by a score of CR&NW workmen and two deputy U.S. marshals.

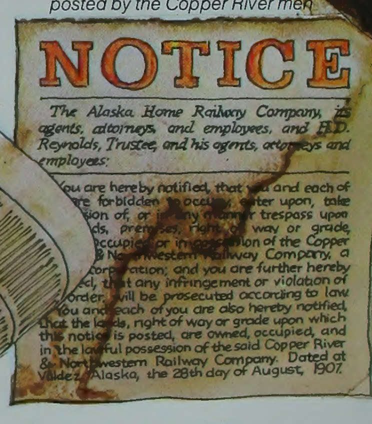
The showdown came during the early morning hours of September 25, 1907. Urged on by their attorneys, who argued that the CR&NW right-of-way claims were invalid, some 200 Alaska Home Railway workmen headed for Keystone Canyon, paced by their foreman, mounted on a horse. None was armed, but all had been issued picks, shovels and axes.

". . . Deputy Marshal Edward C. Hasey shouted a warning to the approaching mob. It was ignored . . ."

Locomotive blows whistle leaving Valdez for the first time, August 4, 1907



The entrance of Keystone was posted by the Copper River men



". . . the Guggenheim brothers, J.P. Morgan . . . were . . . hailed as the men building the Copper River & Northwestern . . ."

J. P. Morgan

"... He stepped forward with a rifle and fired . . ."

Near the canyon's end a barricade barred further passage. Behind it assembled about 30 CR&NW workmen. Deputy Marshal Edward C. Hasey shouted a warning to the approaching mob. It was ignored. He stepped forward with a rifle and fired. When the firing from behind the barricade ceased, five Alaska Home Railway men were wounded. One, Fred Rhinehardt, died later in a Valdez hospital and became a *cause celebre* in Alaska and Washington, D.C.

A Valdez grand jury indicted Hasey on murder charges. In April 1908 his trial opened in Juneau. It was one marked by charges , many of them later substantiated, of jury tampering and manipulation of witnesses. Hasey was found not guilty of murder. But he was convicted of assault with a deadly weapon, and sentenced to two years in prison. In a subsequent appeal, which was denied, he was to argue that "others should have been prosecuted instead of myself."

EPILOGUE: The Shootout at Keystone Canyon had little effect on the collapse that same year of the Alaska Home Railway and the later conviction of Reynolds on mail-fraud charges. But the incident was to echo for years throughout Alaska and in Washington, where anti-monopoly feelings ran high.

Like those in Valdez, the 5,000 hopefuls drawn to Katalla (Where the Rails Meet the Sails) were jilted. Following winter storms that ripped out breakwaters and a pier, the CR&NW moved its railhead again, this time to Cordova, 75 miles to the northwest.

Heney never lived to see the winning of his Cordova gamble. He would have loved it, particularly when the last steel links of the 1,500-foot Copper River bridge were joined just hours before the spring ice breakup ripped out the temporary supports. The first CR&NW train into the copper mines at Kennicott in 1911 carried on the locomotive's front a picture of Heney, the "Irish Prince," who had died the previous winter. The CR&NW was to go no further than Kennicott and ceased operations in 1938 when the mines closed for good.

The entire drama, from the Shootout at Keystone Canyon to the completion of the 198-mile Copper River & Northwestern Railroad can be found in the novel of Rex Beach, *The Iron Trail*. But it reads equally well as non-fiction.

Jim Faber is a Seattle writer who has traveled widely in Alaska. His book, An Irreverent Guide to Washington State is now in its second printing.

Ted Leonhardt, who created the illustration, is a Seattle designer and illustrator who serves Alyeska Reports as designer and art director.

Extent of the Alaska Home Railway's rails

First and only locomotive of the Alaska Home Railway

Keystone Canyon Construction

By Mark Godwin

Shootouts in Keystone Canyon (page 8) are a matter of history. But events there continue to make news with construction of the trans Alaska pipeline.

The trans Alaska pipeline, all along its 800-mile route, crosses many obstacles, both natural and man-made. The frigid North Slope, the imposing Brooks Range, the migration paths of the caribou, the Yukon River, highways and tundra all stand between Prudhoe Bay oil and its destination of Valdez.

But one of the most challenging sections of the pipeline route — indeed, perhaps the most difficult four miles of the project — is not above the Arctic Circle nor high in the Brooks Range but a scant 18 miles from the Valdez Terminal in Keystone Canyon.

Keystone Canyon is as picturesque a piece of Alaska as can be found anywhere. The roiling waters of the Lowe River flow through the center of it. Sheer cliffs of rock rise on both sides into the low clouds, while green trees and shrubs cling precariously to the steep slopes.

Numerous waterfalls, including famous Bridal Veil Falls, tumble over the edge of the canyon and plunge through the clouds. The historic wagon trail that used to lead out of Valdez can still be seen from the highway on the other side of the river.

Where miners and homesteaders once trudged laboriously with their life's possessions, now rumble the trucks and heavy equipment being used to build the pipeline. But it's a toss-up as to who had it tougher, the miners and homesteaders of old or the engineers of today.

The ghosts of Alaska's pioneers must have chuckled when the pipeliners came up against Keystone. Imagine their glee at the thought of hundreds of men and millions of dollars in equipment being stymied by the same terrain that they once crossed with such difficulty on foot and in buckboards.

But like those pioneers, the engineers of Alyeska and its contractor Morrison, Knudsen-River did not give up.

Pooling their hundreds of years of pipeline construction experience, they launched a battle that covered two full construction seasons. Modifying office plans in the field and standard equipment in construction camp shops, they worked a total of ten months, using nearly 200 people a day, finally finishing most of the job in September.

The pipeline rests now high atop the east wall of the canyon. To have built it in the bottom would have required digging up the existing highway, requiring lengthy road closures and great public inconvenience. The danger of rock and snow slides prevented anchoring the line to the side of the canyon walls.

The battle to build the canyon section began in the late spring and early summer of 1975 when Jack C. Cave, Alyeska senior construction engineer, arrived with orders to clear a right-of-way in the canyon.

Cave, a burly, craggy-faced construction veteran who had been working on a huge port expansion project in Seoul, Korea, arrived in Alaska expecting to work on the tanker terminal in Valdez but instead was handed the Keystone Canyon job as a welcoming present.

Cave and MK-R site manager, Jack Owens, got the crews down to business immediately. Men and machines attacked the canyon from both ends, north and south. Since the two ends, or faces, are the steepest points in the canyon, work went slowly. Tracked vehicles were the only machines that could negotiate the slopes, and everything needed at the top to start with had to be pulled there by huge Cats or dozers.

Indeed, one section of the north face, which appears to go nearly straight up, was named "Walking Tom" in honor of a foreman who supposedly told his men: "Boys, if you want to get up there, you're going to have to walk, just like old Tom."

Work, however, progressed steadily until the middle of July, 1975, when crews reached a seeming bottleneck at a place named Gobbler's Knob. Huge, overhanging rocks made it unsafe for drillers to work, and unless the drillers could complete their work, nobody else could follow. Getting equipment above the cut was imperative.

A decision was reached to launch an airlift so that crews could work above the rock. And what followed was one of the

Mark Godwin is an Alaska free-lance writer.

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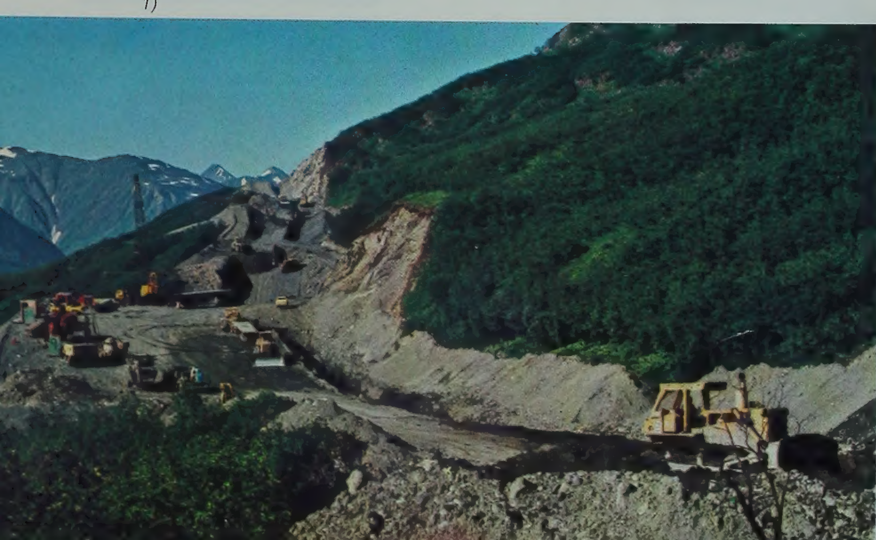

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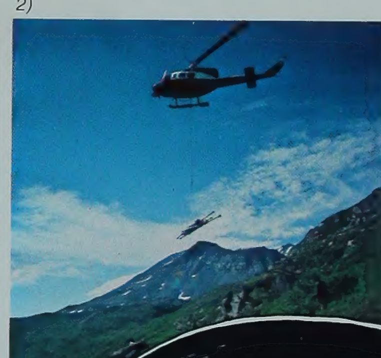

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1) Work proceeds on mountainside, 2) Helicopter hauls supplies, 3) Pipe lengths joined on mountain, 4) Workers unload pipe on steep slope.

1) Winch helps machinery on slope, 2) Equipment gets assist from winch atop Site 3, 3) Rock cut atop canyon, 4) Pipe lowered into ground, 5) Work at Site 3.

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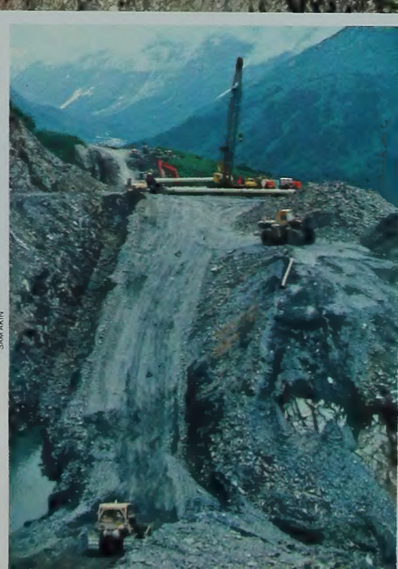

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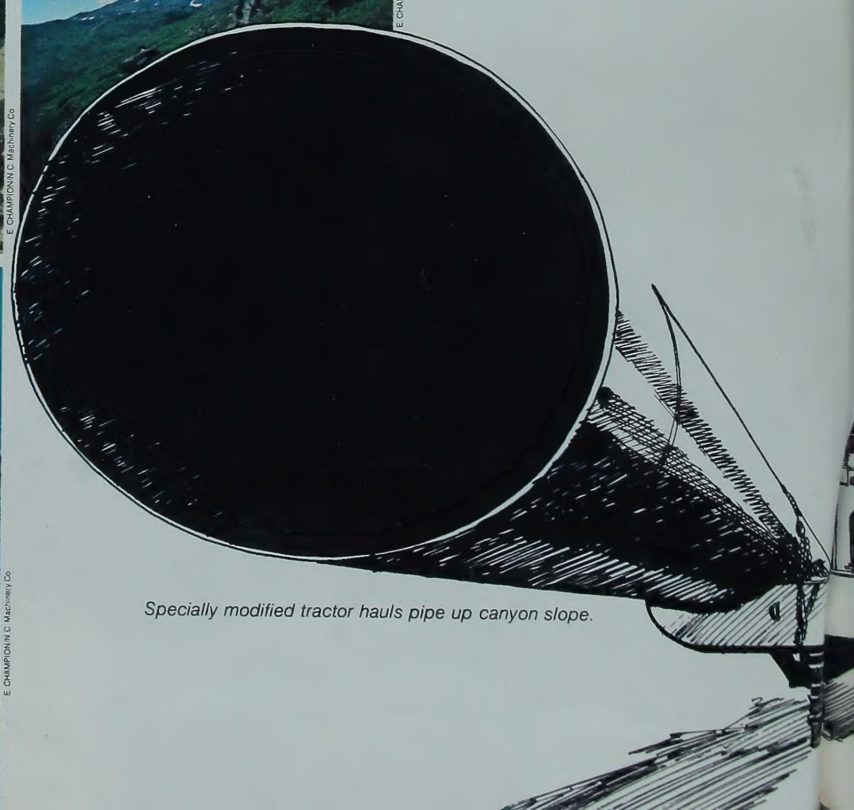

Specially modified tractor hauls pipe up canyon slope.

most dramatic chapters in the history of the pipeline.

Small helicopters first ferried work crews to several points along the top of the canyon to clear patches of land. After the land was cleared, a huge Sikorsky Skycrane, capable of lifting payloads weighing tons, was called in to hoist heavy equipment to the work sites.

One after another, tractors, truck drills and compressors,and dozers were flown up and over the canyon. Smaller machines were lifted whole by the brute choppers, while the big ones were disassembled, the parts lifted, then reassembled on top.

For days, the whir of the Sikorsky's blades echoed off the canyon walls. No sooner would a helicopter set a piece of equipment down than it would lift off again for another load.

The airlift broke the bottleneck. Keystone work could now be attacked from eight places instead of two, and by the end of the 1975 season most of the necessary basic construction work had been completed.

When the winter snows came, some 300 inches of it, the work was called to a halt. However, in May of this year, the effort began again with Don Hand as MK-R site manager. Additional roads were built. Massive amounts of rock were moved while new techniques were developed for moving pipe up the steep canyon slopes.

Permission was received for construction of a new switchback road up the north face. Men and machines cleared the last of the snow, built the road and started work preparing a ditch for the pipe.

The trip up and down the canyon still was so tortuous that it was cheaper to build a rock crushing plant at the top of the canyon than to truck gravel back and forth. The crusher processed 40,000 yards of material before it was through.

The steepness of the approaches also caused crews to pre-tape pipe at the bottom of the canyon so that the cumbersome taping machines wouldn't be forced to make the harrowing journey up and down.

At a place called Site 3 with a 60 per cent grade drillers and blasters had to carve a huge notch out of rock in order to lay the pipe. About 120,000 yards of more than a half-million yards of rock moved in the entire canyon were blasted out at that spot.

To keep waterfalls and streams clear during construction numerous catch basins were built to contain the silt and allow it to settle before the water plunged down the cliffs into the view of tourists below.

Getting pipe up the north face also proved difficult. Choppers could not safely lift 80-foot sections of pipe; pipe trucks couldn't negotiate the slopes, and dozers and tractors couldn't drag the pipe up hill without damage.

The solution to the problem, when it was finally found, looked like something out of a Ray Bradbury book of science fiction.

Roland Cain, below-ground construction superintendent for Alyeska, and Guy Owens, assistant superintendent for Morrison, Knudsen-River, dreamed it up and Don Mackey, MK-R master mechanic at Sheep Creek Camp, put it together.

Developed was a bulldozer with the blade taken off the front and the ripper removed from the back. Crossbars and cradles were installed in their place. Eighty-foot sections of pipe were then lowered onto each side of the dozer, placed in the cradles, and strapped in, parallel to the dozer. The dozer, assisted by another, then slowly clanked its way up the switchback road. At every sharp corner the operator had to hydraulically raise and lower the sections as they hung out over the edge of the canyon, turning in spurts, going first forward, then backward, then forward again as 80-foot pipe bobbed over shrubs and rocks on the narrow road.

Nearly half an hour after they began their journey, the two dozers reached the top of the canyon. Workers and foremen congratulated one another. Cameras clicked. Hands were shaken.

One week later all the pipe was up the north face. The pipe gang arrived and by the end of September construction on Keystone Canyon was history.

Clean-up crews then went to work on the switchback roads, putting them "to sleep", which in construction parlance means restoring them to their natural appearance. Next year tourists will drive up Keystone Canyon, marvel at its beauty, take pictures of Bridal Veil Falls, and never realize that they are surrounded on one side by the spirit of Alaska past in the old wagon trail, and on the other by the spirit of Alaska present in what may be the hardest four miles of construction on the trans Alaska pipeline route.

In all, Keystone Canyon contains 23,000 feet of pipe. In one 2,500-foot section on the north face, the pipe rises 840 feet. In only 2,300 feet on the south face, it drops 820 feet. In between, the pipe goes up and down like an elevator, through a path once blocked by some of the most difficult rock anywhere.

"Journalists keep asking me about this so-called 'critical section' of the pipeline," said Cain on the day the first piece of pipe went up the north face. His eyes twinkled with accomplishment.

"Hell, there ain't nothin' critical unless it can't be done."

And because of men like Cain and Cave and the other 198 or so workers who could be found there on any given day for ten months, Keystone Canyon wasn't critical at all.

It was being completed. And all in good time.

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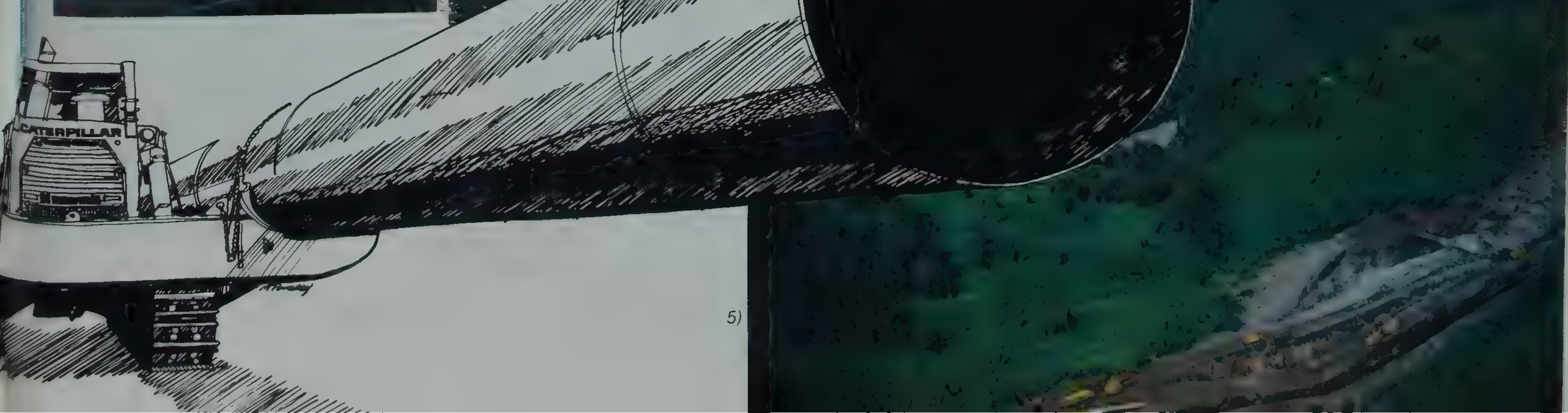


Alyeska's Earthquake Monitoring System

By John Scott

One of the most significant of Alyeska Pipeline Service Company's engineering and scientific achievements may be development of the earthquake monitoring system which will be used once the line goes into operation.

The special system will continuously monitor any earthquake activity along the route and provide virtually instantaneous notification and analysis of the seismic motion to a master station at the Valdez Terminal.

Not that Alyeska is expecting any pipeline earthquake damage. The earthquake design criteria for the trans Alaska pipeline system approach those for nuclear power plants and exceed building code requirements for public structures.

The 800-mile pipeline route has been divided into five seismic zones and an earthquake design level has been established for each zone. The design magnitudes range from a mild quake of 5.5 on the Richter scale in the zone on the North Slope to extremely severe quakes of 8 to 8.5 on the Richter scale in the Alaska Range and near the Valdez Terminal of the pipeline. All pipeline facilities within each zone are designed to withstand the maximum expected quake — one with a likelihood of occurrence estimated to be once in two- or three-hundred years.

The monitoring system was conceived by Dr. Douglas J. Nyman, Alyeska seismic engineer, and design engineering was completed by Nyman, several other Alyeska engineers and consultants from the University of Illinois.

The system consists of a computer-oriented, communications surveillance package of strong-motion accelerographs located along the pipeline route from Pump Station No. 1 south to Valdez. Overall, the system resembles the computer production-control systems now being used by major oil companies for remote operation of fields in many sections of the Lower 48 states.

Unlike the seismograph which records small ground motions due to earthquakes thousands of miles distant, a strong-motion accelerograph measures only the strong motion in its immediate area. While the seismograph presents its information in a form difficult to assess in terms of design and construction considerations, the accelerograph, recording only motions that probably would be noticeable to a person nearby, provides information that can be utilized by the design engineer.

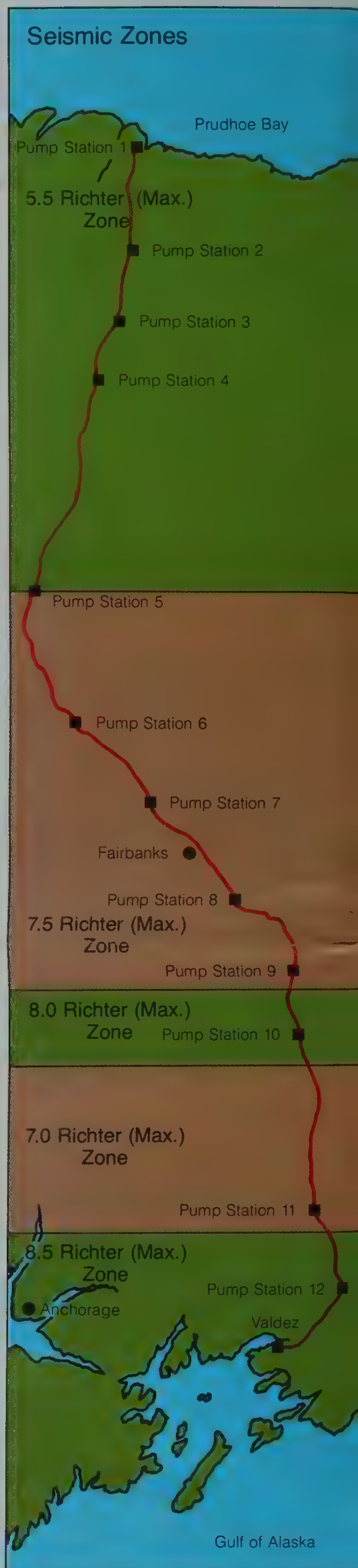
The strong-motion instrumentation used in the Alyeska system is composed of an acceleration sensor unit and a modular electronics panel about two feet square and five feet high. The modular assemblies, packaged by Sundstrand Data Control, Inc., will allow greatly simplified maintenance.

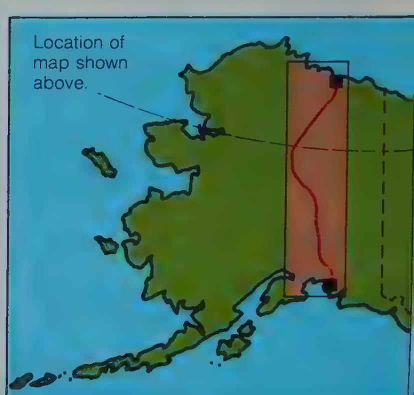
Three sensors in the system will provide the acceleration information. Two horizontal sensors, oriented 90 degrees to each other, will register motion on that plane. The third will measure vertical motion. The sensor assemblies will be mounted on protected concrete foundations on bedrock or otherwise stable soil. Signals from them will be fed into the electronics panel at each remote location. Eleven such units will be set up at selected sites along the 800-mile pipeline route.

The accelerometer provides its signal as an analog, or measurable voltage, reading. These voltage signals are interpreted electronically 200 times each second, and converted to a numerical value suitable for computer processing. A microprocessor, or microcomputer, evaluates this data continuously to determine if the motions have exceeded a certain threshold level, indicating that an earthquake has occurred. Once an earthquake has been detected, the data is channelled to a magnetic cartridge tape and recorded for the duration of the event. The tape data can be retrieved manually for later scientific analysis.

During an earthquake, the microprocessor evaluates earthquake data to describe the earthquake severity in engineering terms. Using the raw acceleration information, system computers analyze the energy content of the earthquake in terms of velocities, accelerations and structural response levels and weigh the likely impact of the quake on the pipeline system in the affected area.

Thus, when the Alyeska monitoring system senses an earthquake along the pipeline route, it immediately will send alarm signals to the Valdez Operations Control Center over the pipeline communications system. Once the earthquake is over the terminal computer at Valdez will automatically poll each of the station instruments for the data recorded. About 30 to 40 seconds will be required to transmit the approximately 40 pieces of data from each instrument, depending on how much information each instrument has to send. Auxiliary information describing system





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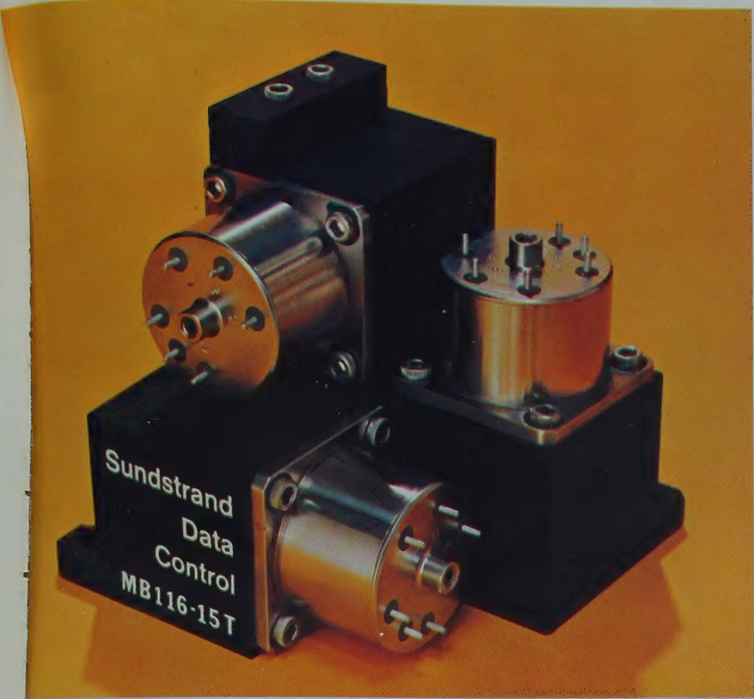
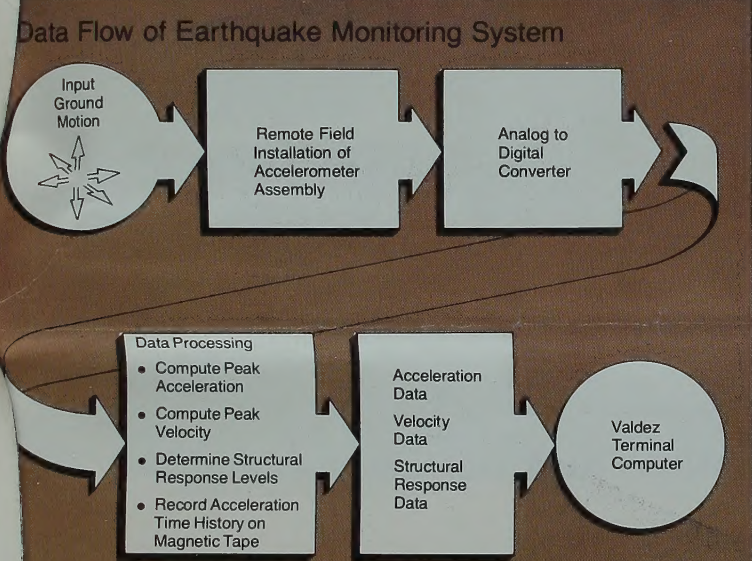
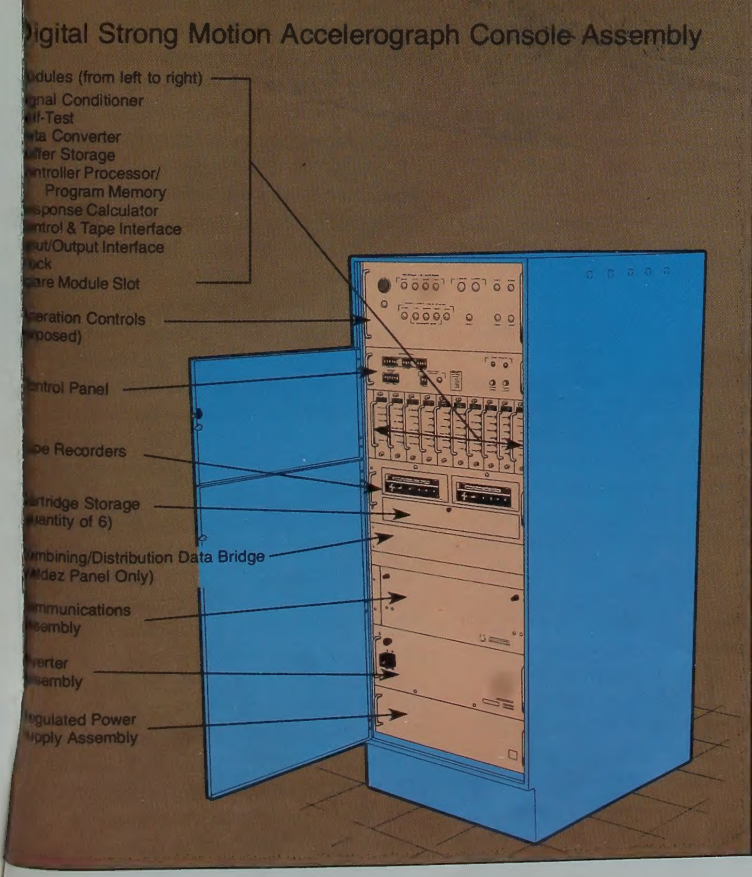


Accelerometer Assembly





Art and photo courtesy of Sundstrand Data Control Corp.

fault status will also be sent as a check of the integrity of the instrument itself.

The data will be stored in a terminal computer master data file. And after all of it has been collected, a second program will be run on the terminal computer to confirm there was an earthquake, determine how severe it was and fix the approximate location of the epicenter.

The system will then estimate levels of shaking that occurred at each station along the line. And within minutes after the event, Alyeska should have enough information to decide quickly (1) whether a shutdown is necessary and (2) where to go to inspect the line and what types of damages to look for. It will not give definitive yes or no answers about whether conditions are safe, however. These are decisions to be made by Alyeska operations personnel using the data from the monitoring and other control systems.

The major point is that Alyeska will be collecting the best available data along the route to describe severity of a particular earthquake enabling operators to decide whether to shutdown the pipeline and how to go about inspection. Otherwise, the pipeline might be shutdown needlessly because of relatively minor earthquake activity.

There are two independent communication routes to each instrument. If there is a break in a microwave communication path due to the earthquake, data can be collected via satellite. If the terminal computer at Valdez breaks down there will be a back-up keyboard and printer available to poll each instrument manually for data. Each instrument also has a memory for storing key parameters processed for ten earthquake events should a major shock be followed by numerous after-shocks within an hour or two. The tape units have the capacity for recording one hour of earthquake data.

Since the earthquake monitoring instruments are in remote locations and exposed to extreme environmental conditions during long inactive periods, steps have been taken to assure their operation when needed. This is accomplished through a built-in, self-check capability. Once commanded to check itself out, the instrument exercises its accelerometer along each axis independently and the motions are recorded and processed and all of the alarms and data are transmitted to Valdez just as though there were a real earthquake. Periodic exercises of this type will verify the system's ability to function properly in an actual earthquake.

Alyeska believes it has achieved its basic objectives with the monitoring system.

Earthquake activity along the route can be detected immediately so that appropriate action can be taken, including shutting down the pipeline if necessary.

The system will provide data to justify a decision not to shut down if the earthquake motion is not severe. And the system will make it possible for Alyeska to continue pumping valuable crude to Valdez following an earthquake, knowing that the pipeline system has not been subjected to motions approaching design limits.

Tanana suspension bridge completed (above) Line moves over Thompson Pass (below)

300-foot high boiler stack hoisted at Valdez

Progress Report

July, August and September were the busiest months of the 1976 pipeline construction year, as work on pipeline, pump station and Terminal facilities passed the 80 per cent completion mark, and a peak work force between 20,000 and 22,000 was sustained for most of the duration of the quarter. Indications were that the worker level would begin tapering off in October.

Nearly 700 miles of the 800-mile pipeline were in place by early September, with pipe installation continuing toward completion in the fall. With the exception of remedial and repair work, all pipeline welding was nearly finished.

About half of the line has been hydrotested. In hydrotesting, the line is filled with water and the water pressure increased to at least 125 per cent of the maximum operating pressure for a 24 hour period. Maximum operating pressure may vary from place to place depending on such factors as proximity to pump stations, elevation and ground topography.

A major milestone passed in July was completion of the installation of vertical supports, although some remedial work remained. Nearly 78,000 support members have been installed to support 425 miles of above ground pipe.

Insulation for the above-ground portion of the line was more than three-quarters complete by late September, and the majority of 120,000 thermal devices required in certain portions of the pipeline route were installed. Thermal devices are installed deep into the ground through the top of vertical support members. These units circulate liquid ammonia through natural convection and insure the stability of pipeline support structures by keeping soils and sub-soils in a permanently frozen condition.

Resolution of engineering problems allowed work in three areas critical to the pipeline construction schedule. These areas were Keystone Canyon and Thompson Pass near Valdez, and Atigun Pass in the Brooks Range far to the north.

The more than four miles of right-of-way preparation and ditching required to cross rugged Keystone Canyon, approximately 16 miles north of Valdez was finished in September. Welding of pipe was completed in this area by the end of September, with ditch backfilling and hydrotesting to be accomplished later this fall.

Approximately one mile of critical work through the 2,100-foot high Thompson Pass was concluded. Right-of-way clearing was finished in August, ditching and welding was to be completed in October and backfilling and hydrotesting were scheduled to be finished soon after.

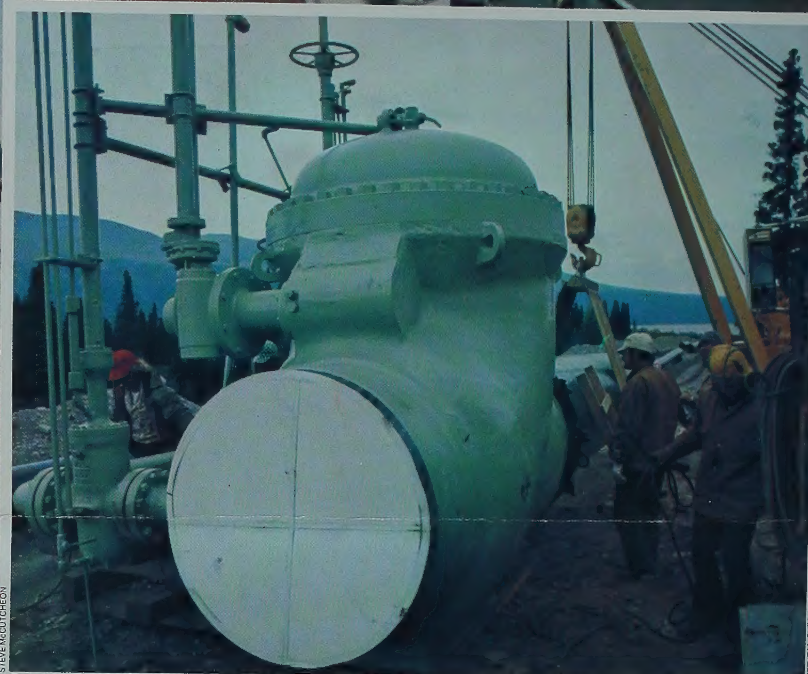
Ditching on the north side of 4,700-feet high Atigun Pass began in mid-July. Work commenced in early August on 2½ miles on the south side of the pass.

All of the 12 major pipeline bridges required at larger rivers and scheduled to be built this year were finished. Among those completed was the 1,200-foot free-span suspension bridge across the Tanana River, the largest suspension bridge in

STEVE McCUTCHEON

Pipe gets insulation

JIM COCCIA



STEVE McCUTCHEON

Pipe mounted on Yukon River bridge (above) Valve lifted into place (below)

Alaska and second longest bridge in the state.

Nearly all of the 62 remote gate valves required for pipeline operation were installed by September. To operate the valves from the Valdez Control Center, microwave signals will be sent first to pump stations. Orders will then be transmitted from pump stations to valves via VHF radio signals. The valves will be used to stop oil flow in the event of a malfunction at any point along the line. Installation of generation units to power the valves was underway at many sites.

Work progressed rapidly at all pump stations during the summer, with overall construction passing the three-quarter mark in September.

Installation of pumps, turbines, mainline corridors, ancillary buildings, fuel lines, piping and tankage was essentially finished at pump stations 1, 3, 4, 8 and 10 by late September. Along with Station 5, equipped with a large relief tank and one fuel tank, these stations will be needed for the initial operating level of 600,000 barrels of crude oil per day.

At stations 6, 9 and 12, which will be brought into operation for the 1.2 million barrel-per-day operating level, significant progress was made on the erection of buildings, interior partitions, installation of electrical conduit, heat-medium piping, pipe supports, fuel lines, mainline corridors and tank construction. Hydro-testing of crude oil and turbine fuel tanks was essentially completed at nearly all stations by September, with mainline pipe hydrotesting continuing at several stations in the fall.

Pass-through stations 2, 7 and 11 were expected to be completed by mid-October. These stations will become pumping stations when operations are expanded to the 2-million-barrel-a-day operating level.

Although random material shortages at the Valdez Terminal affected work sequencing, and limited bed space for workers was a problem, work on various facilities advanced quickly during the long summer daylight hours.

Piping, structures and buildings for the impound basin in the ballast water treatment area were finished in August. Hydrotesting of outside piping and tanks was completed in September. Insulation on outside lines and other measures to prevent freezing were also installed.

At the power generation and vapor recovery area, work in July was concentrated on earthwork, concrete pours, equipment installation, piping emplacement and steel erection. Knock-out drums and scrubbers were installed in August, and incinerator piping was complete in September. Critically needed sections of prefabricated pipe were received at the Terminal in August.

At the East Tank Farm, all but one of fourteen 510,000-barrel capacity crude-oil storage tanks have been hydrotested. Twelve of these tanks at the East Farm will be required for the 600,000-barrel-per-day operating level.

Internal components and door plates were installed on tanks 15, 17, 16 and 18, at the West Farm in September. Tanks 15 and 17 were also hydrotested during this month. Work began on underground oil, water and sewer lines to the Ballast Treatment Plant separation units. The upper reinforced earth wall was finished in September, and activity began on the west fire-water pumphouse.

The Operations Control Center building was completed, with the exception of computer and communication system installation. The administration and maintenance buildings were also finished.

Work continued on berths 1, 4 and 5. By September, installation of marine structures, piping, electrical and control equipment was completed at Berth 4. At Berth 5, roadway concrete, turn-around and loading dock were finished.

Alyeska Reports

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Alyeska Pipeline Service Company has committed itself to keeping the public informed about its progress in the design, construction and, eventually, operation, of the trans Alaska pipeline.

To help meet this commitment, Alyeska has undertaken the quarterly publication of this magazine, *Alyeska Reports*. Your comments and suggestions are welcome.

Alyeska Reports is published quarterly and is produced by the Public Affairs Department, Robert L. Miller, manager.

Alyeska pipeline SERVICE COMPANY

Waiver request based on results of British tests

Alyeska's request to the federal government to exempt from repairs a number of field girth welds does not mean that Alyeska asked the government to approve a defective pipeline.

Quite the contrary. The strength and integrity of the trans Alaska pipeline will in no way be impaired.

Special destructive tests, involving welds like those for which exemptions are asked, have demonstrated that the minor irregularities found in such welds do not require repairs. The tests revealed that the small irregularities are "completely innocuous" and that questioned welds are able to withstand levels of stress far beyond the maximum for which the pipeline was designed.

The welds included in the exemption request were either buried in permafrost, in flood plains of rivers or under rivers where repairs would be extremely difficult. All involve only those irregularities, as revealed by actual X rays, which the tests demonstrated will not jeopardize the integrity of the welds or the safety of the line.

Alyeska originally had planned to ask for exemptions on only 11 such welds. The Department of Transportation, however, asked the firm to make application for all exemptions which might be sought. Alyeska, thereupon, filed requests on 612 welds containing minor irregularities, not in strict compliance with federal regulations, but which the tests proved to be harmless.

Repair of the welds continues as the company awaits Federal response to the waiver request, and as of September 26, Alyeska had repaired all but 320 of the 612 welds in question. Waiver requests are being withdrawn for each weld repaired.

Alyeska based its request on fracture mechanics studies carried out by the British Welding Institute of London and the Cranfield Institute of Technology in Cranfield, Bedfordshire, England. The testing organizations conducted about 900 tests on specimens cut from actual trans Alaska pipeline welds to arrive at their conclusions. Representatives of the Department of Interior and Transportation observed the tests.

Alyeska initiated the British testing program after a 1975 Alyeska audit of welds revealed 3,955 irregularities of all kinds. More than 90 per cent of those already have been corrected.

Despite the workload imposed by the weld and radiographic resolution program, Alyeska expects to complete the project as planned by mid-1977.

At Prudhoe Bay, drilling and construction work moved into its final phases as oil companies prepared to deliver 1.2 million barrels of oil daily to the trans Alaska pipeline from 9.6 billion barrel field in mid-1977.

Special earthquake monitoring equipment is being installed at pump stations along the 800-mile pipeline route to provide Alyeska with almost instant notification and analysis of any seismic action along the 800-mile route.

Waivers are being sought on some buried pipeline welds in which radiographs revealed minor irregularities. Extensive tests by British laboratories demonstrated that such irregularities are "completely innocuous" and verified the integrity of the welds.

Between 20,000 and 22,000 workers were employed on the pipeline this summer as 700 miles of the 800-mile line were put in place. More than half of the line has already been hydrotested with water at 125 per cent of the maximum operating pressure.

Contractors battled some of the roughest terrain on the entire pipeline route to complete a tough four-mile section of pipeline in historic Keystone Canyon. Crews called on a huge helicopter and built special pipe-hauling tractors to help finish the job.